

The Case for Technology for Developing Regions

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Intel Research Berkeley

- **Historically focused on sensor networks**
 - Several technology transfer paths in progress
- **Leader in the networking space:**
 - Four papers (from IRB alone) at SIGCOMM
 - SIGCOMM WDTN conference led by IRB
 - Work on PlanetLab, “networks as databases”
- **Home and urban computing initiatives**
- **Focus for Today:**
 - Technology for developing regions

Claims:

- **Information & Communications Technology (ICT) can make a difference**
 - ... but current “First World” tech is a bad fit
 - ... and thus a need for research.
- **ICT is not for web access (per se)**
 - ... but for health, education, government, commerce – the real problems
- **Moore’s Law helps**
 - ... but it’s not sufficient.
- **The Roles for Intel**

The “Base of the Pyramid”

- **3-4 billion people**
 - Equivalent purchasing power < \$2/day
- **Swells to 6-8 billion over the next 25 years**
- **Most live in rural villages or urban slums**
 - Movement towards urbanization
- **Education levels are low or non-existent**
 - Especially for women
- **Markets are hard to reach, disorganized**

Outline

- **Introduction**
- **Existing Impact**
- **Moore's Law**
- **Intel's Roles**
- **Conclusion**

Sustainable Impact

- **Public goods (via taxes)**

- E.g. fire department, disaster relief, primary education
- Ideally: save money and improve service
- Transparency to limit impact of corruption

- **Private projects**

- Must be “non-loss” companies
- Increase income or reduce costs
- E.g. Vocational education/training, entertainment
- Needs capital, OK to kick-start with charity
- Scales via franchising (individual entrepreneurs)

Public good example: River Blindness

- **ICT used to help eradicate blackfly that carries river blindness in West Africa**
- **Network of real-time hydrological sensors, satellites, and forecasting software determined best time to spray larvicide**
- **Protects 30 million people from infection**
- **Freed up 100,000 square miles of land – capable of feeding 17 million people**

Other public good examples

- **Water quality testing**
- **Primary education**
 - Positive impact shown in some early projects
 - Still need teachers, but helping them is critical.
- **Disaster relief (and prevention?)**
 - Chinese dam failure killed 80,000 – 230,000 (1975)
 - World Bank: 0 of 25 of India's dams are OK
 - 2004 Tsunami:
 - Need for communications
 - Coordination of donations & volunteers

BoP as a Market

- **Being poor is expensive**
 - 2-10x cost for water, medicine, credit
 - Factors: distribution, security, small quantities
 - => **money already being spent!**
- **The poor have disposable income**
 - TV/radio
 - Pressure cooker
 - 7% of income spent on telephony in rural Bangladesh

Private example: Grameen Bank—Bangladesh

- **Owned entirely by the poor**
 - Began in one village in 1976
 - 2.6 million borrowers (95% women), over 1,000 branches in over 42,000 villages. 12,000 staff.
- **Has loaned more than US\$3.9B since inception**
 - Over US\$3.5B repaid with interest (98.75% recovery rate); \$290M loaned in the last 12 months.
- **Has never accepted any charity**
— has always been a profitable social enterprise
- **46.5% of borrowers have crossed the poverty line**

Grameen Telecom

A Disruptive Societal-Scale Business Model



- 'Village Phone' is a unique idea that provides modern telecommunication services to the poor people of Bangladesh.
- So far over 95,000 loans of average US\$200 have been given to buy mobile phones.
- **Covers 50,000 of the 68,000 villages**
 - 60M users
 - => Scales!
- **Phone Lady income goes up by >2x**
 - Maintains the system
 - => Works!

Other self-sustaining examples

- **Vocational educations**
 - CDI computer training in Brazil, 800 centers
- **More efficient supply chains:**
 - ICT agriculture kiosks, 4500 in India
 - Remove inefficiencies, reward higher-quality crops
- **Aravind Eye Hospital**
 - US\$10 cataract surgery for a profit
 - 2M patients in 2004, 200K surgeries

What about Moore's Law?

- **It makes this the right time**
 - Along with low-cost wireless (cellular, WiFi)
 - And along with microcredit and franchising
- **However, primary cost is NOT the CPU**
 - Environmental and infrastructure issues impact packaging, discretes, batteries, screen...
 - Drives us toward integrated approach
- **Sharing helps the most**
 - Much better utilization

Roles for Intel

Core Technical Research

- Collaboration with NSF, UC Berkeley

Ethnography Research

- Panel on Wednesday

Development of novel platforms

- Channel Platforms Group, based in Shanghai
 - Product Development Centers: Brazil, India, Cairo

Lead the way: Show that these are viable technology markets!

Early Research Agenda

- **Rural network coverage**
 - Long-distance low-cost links
 - Intermittent connectivity
- **Shared devices and infrastructure**
- **Power issues**
 - Low-power networking/computing
 - Low-cost *quality* power

Ambasamudram Eye Center



- **Aravind Eye Hospital**
 - Tamil Nadu, 5 hospitals
 - But too far for most to walk
- **Goals:**
 - 110 rural health centers
 - Telemedicine
 - Computer-assisted diagnosis
- **Already sustainable!**
 - ... at 65 patients/day

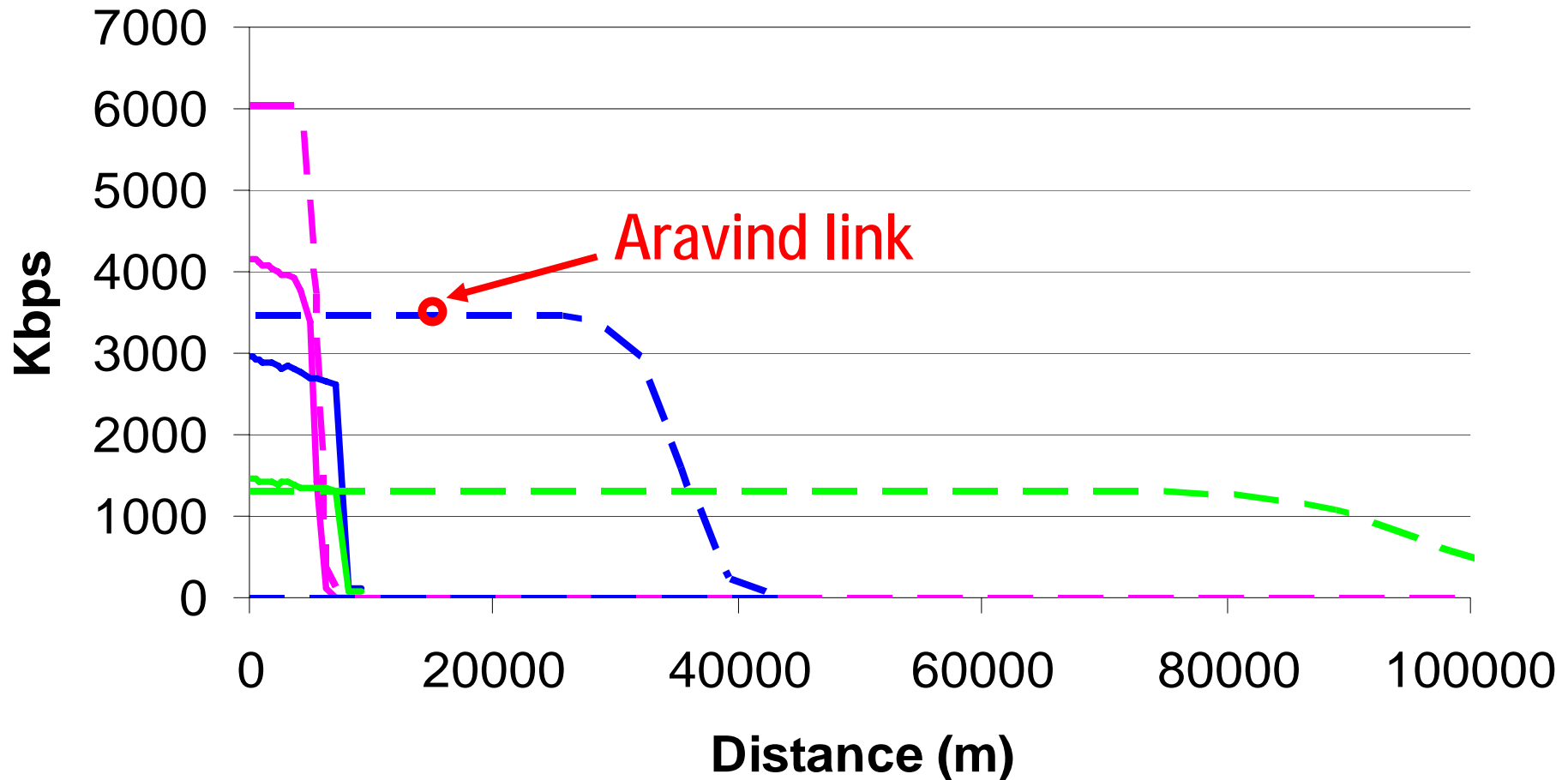
Long-distance wireless

- **Goal: low cost 50km links (\$300?)**
- **Exploit \$5 802.11 chipsets**
 - ... but need new network stack (MAC+)
- **Low power as well (e.g. solar)**
- **Longer term:**
 - Low-cost antenna arrays
 - Voice over IP over these links
 - WiMAX?

Slotted WiFi MAC

- **Move to TDMA with coarse slots**
 - Rate-based flow control (due to high RTT)
 - Exponential backoff is bad for voice
- **Move to bulk acks (like SACK)**
 - Turn off automatic acks
 - Normal timeouts too short
- **Support multiple antennas per pole**
 - “burst synchronization”
 - Turn off carrier sense

New MAC Layer



Normal 11 Mbit
Normal 5.5 Mbit
Normal 2 Mbit

Slotted 11 Mbit
Slotted 5.5 Mbit
Slotted 2 Mbit

Intermittent Networking

- **Developing-region networks rarely connect end-to-end**
 - Power, weather, reliability issues
 - Sometimes *intentionally* intermittent:
 - Low-earth orbit satellites: connect only while they are overhead
 - “Mules” – moving basestation collects data
Basestation could be on a bus/motorcycle (DakNet)
 - But clearly fine for e-mail and voice mail..
- **Extended coverage:**
 - User may periodically enter the coverage area (e.g. market/school)
- **Internet doesn't really handle this well...**
 - “Delay-tolerant Networking” Research Group (dtnrg.org)
 - Papers in last two SIGCOMMs, and the next one
 - Led by Kevin Fall of Intel Research Berkeley

DTN and Cambodia

- **Testing the impact of intermittent networking in Cambodia**
- **Rural “Community Information Centers”**
 - Often the only local source of information
 - Connectivity varies from good to very bad (cellular modem)
 - Need for local content (Khmer language)
- **DTN Pros:**
 - **Cost:** better use of resources, more tolerant of problems
 - **Reliability:** delay hides transient problems
 - **Coverage:** Intermittent coverage >> full time coverage
- **Con: Not really interactive**
 - **But great for e-mail with appears to be 50% of traffic**
- **Planned test deployment in January**

Other challenges

- **Low-cost complex sensors**
 - Water, air and soil quality
 - Disease detection
 - Potential role for Intel's Digital Health group
- **Custom ICs**
 - Better integration reduces cost, power
- **Power systems, replace lead-acid batteries?**
- **Literacy/training support**

Claims revisited:

- **Technology has made a difference**
 - ... for health, education, government, commerce – the real problems
- **Need a sustainable model**
- **Need a holistic, integrated solution**
 - ... sharing is more important
- **There are many roles for Intel**
 - Technical and ethnographic research
 - Novel products designed for these regions
 - Creation of markets and ecosystems

For more details....

- **Companion article to this talk:**
“The Case for Technology for Developing Regions” – E. Brewer *et al.*
- **IEEE Computer, June 2005**
- **Berkeley web site:**
 - **Tier.cs.berkeley.edu**

Q & A

Literacy

- **Idea: make better use of speech recognition**
- **Novel speech recognition:**
 - Easy to train, speaker independent
 - Any language or dialect, but small vocabulary (order 100 words)
 - A non-IT person can train the speech for her dialect
- **Early results:**
 - 40 samples in Tamil, most collected in India
 - **98% recognition accuracy** on digits, simple commands
 - Application trials this summer
- **Have 2mm .13 micron chip design, 19mA active**
 - 10000x less than Pentium, 100x less than X-Scale

Tsunami Disaster



- About 10,000 dead in India, 6000 in Tamil Nadu
- Small ICT victories:
 - Veerampattinam: loudspeakers used to clear the beach after first wave
 - Only 1 life lost (of 6300)
 - Nallavadu: former kiosk worker called from Singapore and warned the village => **no lives lost (of 3600)**
 - Nagapattinam: HAM radio set up to announce relief info, missing persons

The Installations



Villianur, 80ft tower
Station
24 dB antenna



Nallavadu, 60ft
Master, 24 dB
antenna



Aravind Eye Hospital, 70ft
Station, 18 dB antenna



intro impact

Moore's Law

Intel

Conclude

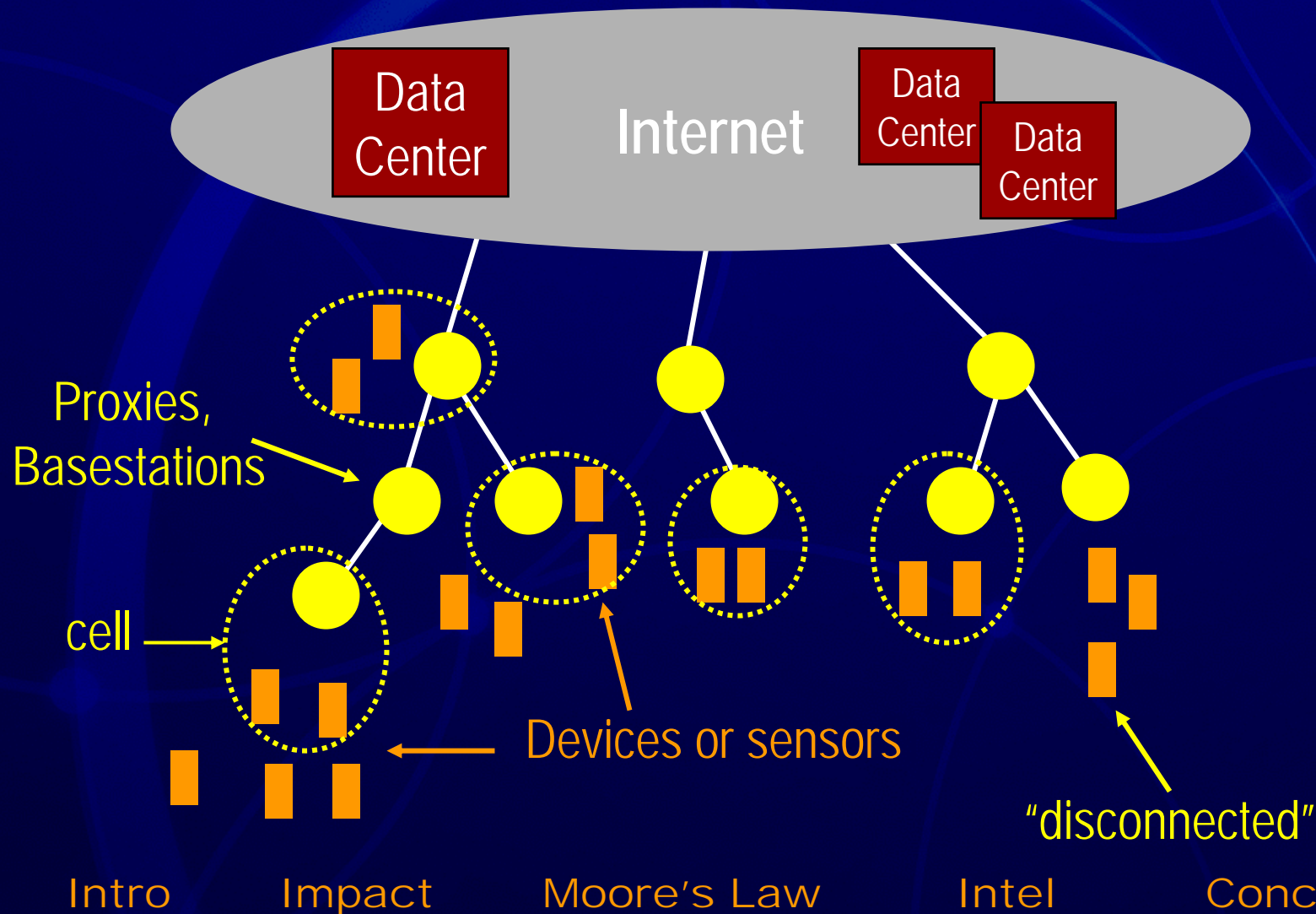
Even the Very Poor Spend

- **Dharavi, one of the poorest villages in India:**
 - 85% have a TV
 - 50% have a pressure cooker
 - 21% have a telephone
 - ... but can't afford a house
- **Even the poorest of the poor in Bangladesh:**
 - devote 7 percent of income to communications services (GrameenPhone)
- **These are valid markets...**

Akshaya Project

- **Kerala E-gov project**
 - Provide e-gov kiosk for every 1000 households
- **Deployed in one district so far (Mallapuram)**
 - Largest wireless network in the world? (400 sites)
- **Partially subsidized:**
 - Subsidized training in “e-literacy”
One person per household
 - Entrepreneurs must make it go after that
- **Looks sustainable, but too early to tell**
- **Working with the technical contractor to study and improve the technology**

General Architecture



More on Dharavi

- **Represents urban poor**
 - 1300 cities with >1M people
 - Urban ICT could reach 2B people by 2015
- **Dense: 44,000 people per square mile**
 - Berkeley: 9700 Pittsburgh: 6000
- **6 churches, 27 temples, 11 mosques**
- **About \$450M in manufacturing revenue**
- **Lots of small inefficient businesses already...**

Services for BoP

- **Top three:**
 - Education (20% of Digital Dividend projects)
 - Credit (micro-loans)
 - Wireless phones